



A STUDY IN INFORMATION PROCESSING:  
ELECTROLUMINESCENT VS TELETYPE READABILITY  
OF WEATHER MESSAGES

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United States Air Force  
L.G. Hanscom Field, Bedford, Massachusetts

Project 7682  
Task 768201

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## FOREWORD

The experimental work reported here is part of the in-house research effort in support of Project 7682 and was performed under Task 768201.

The authors wish to express their gratitude to the following:

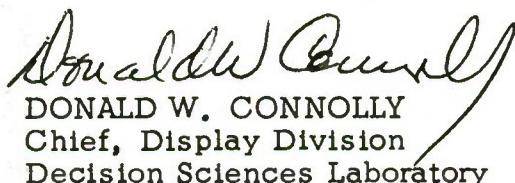
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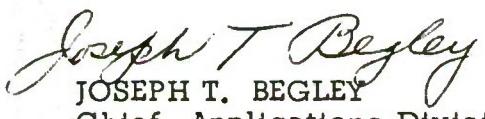
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This technical report has been reviewed and is approved.

  
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A Study in Information Processing: Electroluminescent  
vs Teletype Readability of Weather Messages

ABSTRACT

An investigation was undertaken to provide a human factors evaluation of an electroluminescent display designed for the presentation of around-the-base weather messages.

Time and error data were obtained for 42 Air Force weather, GCA, and pilot personnel in responding to six questions for each of 50 weather messages, 25 of which were presented on an electroluminescent display and 25 by conventional teletype format.

The few significant differences found do not warrant a conclusion that the electroluminescent format employed is inferior to the conventional teletype format.

It is concluded that weather message information processing may be improved by the development of time and error normative data for a standard set of weather messages, thereby permitting the identification of high-error (perhaps error-prone) personnel, by training to improve the interpretation of visibility coding and more specifically, by an improved formating of fractions concerned with visibility. The suggestion for the development of normative data may have applicability for other military information systems.

This study may be of assistance to the display designer and for the training of military and civilian personnel in weather message interpretation. It has value for the improvement of weather message formating as well as highlighting the importance of appropriate personnel selection and training for tasks involving the processing of information in complex displays.

The study further demonstrates the importance of not relying upon premature curbstone judgments of a display feasibility in lieu of an actual experimental test.

## TABLE OF CONTENTS

FOREWORD	ii
ABSTRACT	iii
TABLE OF CONTENTS	iv
LIST OF TABLES	v
I. PURPOSE	1
II. METHOD	1
III. RESULTS AND DISCUSSION	3
A. Electroluminescent vs Teletype Presentation	4
B. Air Force - Air Weather Service Implications	9
C. Implications for Military Information Processing	18
APPENDIX A	21
Weather Messages Displayed by Teletype	23
Weather Messages Displayed by Electro- luminescence	24
Response Sheets with Questions	25
Photographs of Alpha, Numeric, and Symbolic Characters Used on the Electro- luminescent Display (Courtesy of Sylvania Electric Products, Inc.)	39
Instructions to Subjects	41
APPENDIX B	42
Response Times in Minutes and Errors by Subjects and Display Type	43
Errors on Electroluminescent in Station Identification	45
Errors on Teletype in Station Identification	46
Remarks Summary	47
Note on Scoring and the Questions	48
APPENDIX C	50
Detailed Erroneous Responses by Display Type and Subject Group:	
Teletype	51
Electroluminescent	59

## LIST OF TABLES

	Page
I. Mean Response Time in Minutes for Weather, GCA, and Pilot Personnel for 25 Weather Messages by Display Type . . . . .	4
II. Percent Not-Correct Responses for Weather, GCA, and Pilot Personnel by Display Type . . . . .	4
III. Alpha, Numeric, Symbolic Error Summary by Subject Group and Display Type . . . . .	6
IV. Error Frequencies, Percent, and Rate (in percent) for Successive 25 percents of Weather, GCA, and Pilot Subjects . . . . .	10
V. Visibility Errors Involving Fractions Reported as Greater Than, Less Than, or Other Than that Displayed . . . . .	12
VI. Error Frequencies and Types in Reporting Visibility Mileage Involving Fractions . . . . .	13
VII. Frequency Totals and Per Cent Not Correct for Both Displays . . . . .	17

## I. PURPOSE

Although this investigation was undertaken to provide a human factors evaluation of an electroluminescent display which was designed to present around-the-base weather messages, the results have added implications for the formating of weather messages for training of personnel in weather message interpretation, and for military information processing.

## II. METHOD

Forty-two military personnel each read and responded to 50 weather messages. The subjects consisted of 16 weather forecasters and observers from Detachment 6 of the Hanscom Base Weather Station; 8 Hanscom GCA personnel; and 18 Air Force pilots. It was believed that this choice of subject groups would provide differential levels of familiarity or experience with weather message interpretation. Twenty-five weather messages were presented on the electroluminescent display while the other twenty-five were presented in conventional weather teletype. The messages varied in length from fourteen to sixty-four characters. The messages were composed in the Base weather station and were designed to be equated for length and difficulty on a one to one basis for each display format. There was a time lag of six months between the time the messages were composed and their administration to the subjects; the data were collected in the fall of 1963. The task of each subject was to read each weather message and to record answers to six questions for each message. (See Instructions to Subjects, Appendix A). The elapsed time in hundredths of a minute

from the presentation of the first character of a message until the subject completed his responses was controlled by each subject and recorded by the experimenter. (See Appendix A). Half of each group of subjects were presented the electroluminescent messages first, whereas the other half viewed the teletype messages first. Prior to the electroluminescent presentation, each subject received a ten-minute standardized orientation with considerable repetition which presented the electroluminescent format for each letter, numeral, and weather symbol; the test was not begun until each subject signified he was confident of being aware of all the code and format differences. Subjects viewing the electroluminescent display were seated at a distance of three feet from the display, whereas they viewed the teletype presentation from about a foot and a half away. The illumination as measured by a McBeth Illuminometer was 24 foot candles.

Appendix A presents the weather messages employed. The reader, however, should bear in mind that the actual Alpha, Numeric, Symbolic characters viewed by the subjects on the electroluminescent display are as depicted in the photos on pages 39 and 40 of the same appendix. Wind arrows were displayed in fixed positions nos. 31 and 32 on the top line of the electroluminescent display. This appendix further contains the questions to which subjects responded and the instructions to the subjects. Both displays were activated through the same paper tape reader, hence messages were exposed at identical rates.

### III. RESULTS AND DISCUSSION

The results and discussion will consider (A) the electro-luminescent vs the teletype data, (B) implications for the Air Force, the Air Weather Service, and for weather message presentation and interpretation, and (C) general implications for military information processing.

Two different types of analyses were made of the data: (1) response time and error scores by individual subject for each subject group by display type and (2) error categorization by specific weather information in an Alpha, Numeric, and Symbolic framework. Tables I and II present by display type the mean response times and the percentage of not-correct responses respectively for the different subject groups. Table III shows the not-correct response frequencies for the teletype and electroluminescent displays classified according to the Alpha, Numeric, and Symbolic form of the data within each weather message and partitioned by subject group; this classification happens to show an almost identical number of questions asked pertaining to these specific categories for the two different displays. Response times and error frequencies by individual subjects are presented in Appendix B which also contains a note on the scoring and questions, and a summarization of subjects' comments. Appendix C contains a detailed presentation of erroneous responses which should be of assistance in training personnel in the pitfalls of weather message interpretation.

A. Electroluminescent vs Teletype Presentation.

From an analysis of the time and error scores for each group of subjects only one firm significant difference is found, namely the time scores for weather personnel ( $.03 > p > .02$ ). The larger difference in mean time scores for pilots fails to meet the 5% level of significance because of their greater variability.

TABLE I  
Mean Response Time in Minutes for Weather, GCA, and  
Pilot Personnel for 25 Weather Messages by  
Display Type

	<u>Weather</u>	<u>GCA</u>	<u>Pilot</u>
Teletype	10.4	19.3	17.1
Electro-luminescent (EL)	11.7	19.4	19.5

TABLE II  
Percent Not-Correct Responses for Weather, GCA, and  
Pilot Personnel by Display Type

	<u>Weather</u>	<u>GCA</u>	<u>Pilot</u>
Teletype	1.9	7.4	9.8
Electro-luminescent (EL)	2.6	11.2	10.1

Weather personnel have suggested that questions on barometric pressure tendency and cloud types were unfair for both GCA and pilot groups - questions which generated error rates from 87% to 100% for these groups as contrasted with error rates largely below 10% and in no case exceeding 28% for either of these groups for any other specific response category (see Table VII). Five questions on the electroluminescent displays dealt with these matters, whereas only two were so concerned for the teletype displays.\* With the elimination of responses for these questions, the error difference for the GCA group is not significant. Furthermore, when the not-correct responses for these questions are subtracted from the error total for each display group, the remainders in Table III would become 344 for the teletype and 339 for the electroluminescent.

In view of the brief ten minutes' orientation to the altered symbology and formating on the electroluminescent display, it cannot be concluded that the operational use of such a display would result in a performance decrement. The results of this investigation should serve as a warning to those prone to advance curbstone judgments concerning proposed display formats. It had been freely opined with supporting "logical" reasons that use of this particular electroluminescent display would give rise to marked degradation in performance. That an actual test failed to support such opinion strengthens a growing belief of some display investigators that there is probably a point beyond

\*For the EL #12.5, 12.6, 22.3, 22.5 and 23.6; For the TT 22.3 and 22.5 (see Appendix A)

TABLE III

**Alpha, Numeric, Symbolic Error Summary  
by Subject Group & Display Type**

		Teletype GCA n=8		Pilots n=18		Electroluminescent Wx n=16		Pilots n=18		Totals	
		Wx n=16	GCA n=8	Wx n=18	GCA n=8	Wx n=16	GCA n=8	Pilots n=18	TT	EL	
<b>ALPHA</b>											
Station											
Identification	(25)	7	0	0	(25)	6	16	3	7	*	25
Visby & Remarks	(11)	5	21	47	(9)	2	19	48	73		69
<b>SYMBOLIC</b>											
Sky:a	( 5 )	0	0	4	( 6 )	2	4	4	4		10
:b	(22)	2	4	17	(24)	6	3	6	23		15
:c	(18)	7	8	39	(16)	14	25	25	54		64
Wind Direction	( 8 )	0	0	15	( 7 )	3	0	4	15		7
Alpha/Symbolic	( 5 )	4	6	24	( 5 )	2	4	12	34	*	18
<b>NUMERIC</b>											
Height of ceiling or cloud											
cover	( 5 )	3	3	4	( 5 )	1	1	3	10		5
Temperature	( 7 )	0	1	2	( 7 )	0	0	0	3		0
Dewpoint	( 7 )	2	1	4	( 7 )	1	0	1	7		2
Wind Speed	( 9 )	4	2	3	( 7 )	2	0	3	9		5
Baro-Altimeter	( 9 )	0	2	1	( 8 )	2	0	2	2		3
Baro pressure											
tendency & amt	( 1 )	3	8	18	( 3 )	7	21	54	29		82
Visibility	( 8 )	2	13	21	( 7 )	7	9	14	36		30
Cloud types	( 1 )	2	7	18	( 2 )	0	14	36	27		50
Alpha/Numeric	( 9 )	5	13	48	(12)	8	18	59	66		85
	(150)	46	89	265	(150)	63	134	274	400		471
Fractions	( 6 )	4	17	23	( 8 )	7	10	16	44	*	33

Figures in parentheses indicate the number of questions asking for basic weather message data falling within said categories. For explanation of Sky a, b, and c see note on scoring and questions in Appendix B.

which the improvement of physical display characteristics may not be worth the cost. Clearly, in this investigation the most important parameters were a knowledge of weather symbols, codes and formating. There is, of course, the possibility that with increased practice with the electroluminescent symbology and formating, a reduction in error rates as compared with the teletype might result; however, this investigation did not address itself to this question.

Further examination by Alpha, Numeric, Symbolic categories, however, does disclose (see Table III) three significant differences in errors between the two displays:

1. The probability of the error difference being chance in favor of the teletype display in the recording of station letters is less than 5 in 1,000. The specific errors with a frequency breakout are shown in Appendix B with the single most significant error being the recording of D for B with the electroluminescent display. It may be noted there is only one small segment of difference between the electroluminescent presentation of these two letters. It may also be noted that for the teletype display the largest frequency for any specific error was one. One other confusion was identified, namely, the recording of 5 for S, an error which occurred once for EL question 3.4 and six times for EL question 19.6.

2. The probability of the error difference favoring the electroluminescent display for the Alpha/Symbolic information being chance is between 1 and 2 in 100. This classification embraces the codes for such information as "heavy thundershowers" and for visibility remarks such as "scattered variable to overcast." (See EL

messages #8 and #4 respectively). This difference may be explained in terms of information density, i.e., the ratio of occupied spaces to overall linear spaces occupied by the message. It has already been stated that the wind arrows for the electroluminescent display were displayed in fixed positions #31 and #32; since they were preceded by temperature and dew point, this resulted in a varying number of unused matrix positions preceding the temperature/dewpoint information. Accordingly, four of five of the electroluminescent Alpha/Symbolic codes occupied what amounted to terminal positions, whereas only one of the teletype Alpha/Symbolic codes could be considered as terminal - "terminal" here meaning "followed by more than one unused space".

3. The third significant difference between the two displays pertains to the processing of fractions, and the results favor the electroluminescent display. The probability of the difference being chance is less than 1 in 100. It should be noted, however, that this difference is concerned with error frequency alone. A more detailed analysis of errors involving fractions suggests that because of the face-plate junction between electroluminescent matrix positions #18 and #19, the magnitude of specific errors may be greater than the errors most frequently found with the teletype. (See Section B.2).

Another disadvantage of this face plate is that from extreme wide-angle viewing the matrix elements adjacent to the face plate

for positions 1, 18, 19, 36, 37, 54, 55, and 72 are masked, or at least partially so. Thus an N in position #19 could be taken for a V if one were viewing the display from a position sufficiently far enough to the left.

B. Air Force - Air Weather Service Implications.

Although studies such as this are of little value in indicating that "to err is human...",<sup>1</sup> they can be of value in indicating possible ways in which human error may be reduced. Furthermore, it is possible that the term "error prone" may become as useful a term in information processing as has "accident prone" in traffic and industry research.

Whereas in the preceding section the concern was merely comparative between the electroluminescent and teletype presentations, two facets of concern to the Air Force are the performance of the individuals and the effects of specific display coding and formating. The results from this experiment indicate that improvement in weather information processing should be possible from two standpoints: (1) improved personnel processing and (2) altered weather message formating.

1. It is apparent that, regardless of which group of subjects are examined, the major proportion of the errors are made by a minor proportion of the subjects and there are rather sizeable individual

1.

Alexander Pope, Essay on Criticism, 1711

TABLE IV  
 Error Frequencies, Percent and Rate (in percent) for Successive 25 Percents of  
 Weather, GCA, and Pilot Subjects for Both Displays

	<u>Weather</u>	<u>GCA</u>	<u>Pilot</u>
N = 16		N = 8	N = 18
Error Frequencies			
Percent of Errors			
Error Rate (percent)			
Highest Error 25% of Subjects	51 56.8 4.3	99 44.4	16.5 212 39.3
Second Highest Error 25% of Subjects	30 27.5 2.5	56 25.1	9.3 149 27.6
Third Highest Error 25% of Subjects	20 18.4 1.7	39 17.5	6.5 96 17.8
Lowest Error 25% of Subjects	8 7.3 .7	2.9 13.0	4.8 82 15.2
Error Rate (percent)			
Percent of Errors			
Error Frequencies			

differences. Among the weather personnel, total errors for both displays ranged from zero to 18 with a median of 6.5. For GCA subjects, the range was from 14 to 52 with a median of 22, while for pilots the range was from 17 to 55 with a median of 25. Table IV shows that the four weather subjects having the greatest number of errors made more than six times the number of errors made by the four subjects having the fewest errors. For the GCA group the two highest error subjects had almost four times the errors made by the two lowest error subjects, whereas among the pilots (by apportionment) the highest error 25% had about  $2\frac{2}{3}$  times the errors of the lowest 25%. Improved selection, training or more frequent re-training would appear to be needed.

2. If the results from this experiment are not atypical, the formating of fractions in weather messages is in urgent need of improvement. Both error frequency and error magnitude are large enough to give cause for genuine alarm. For weather personnel the error rate for fractions was more than double that of their overall error rate; for GCA personnel it was more than  $2\frac{1}{2}$  times and for pilots  $1\frac{1}{2}$  times the overall error rate. In point of fact, the true ratios of fraction errors to average error for GCA and pilot subjects are even larger than set forth above because the errors on barometric tendency and cloud types should probably be excluded from their average error rates.

Since all questions requiring responses involving fractions were

concerned with visibility, this problem merits a more detailed analysis in terms of error direction, error magnitude, and error distribution among the different groups of subjects because of the criticality of such figures for the safe landing of aircraft.

Table V shows that for the teletype display 32 of 44 errors involving fractions for visibility were reported as greater than the visibility mileage displayed whereas but 11 of 33 errors were so reported for the electroluminescent display. However, the actual mileage reported as greater than that displayed is larger for the electroluminescent than for the teletype.

TABLE V  
Visibility Errors Involving Fractions Reported Greater Than, Less  
Than or Other Than That Displayed

	<u>Greater</u>	<u>Less</u>	<u>Other</u>	<u>Totals</u>
Electro-luminescent	11	15	7	33
Teletype	32	3	9	<u>44</u> <u>77</u>

Although the numerals and symbol constituting the fractions were sequentially shown in both displays (i. e., they occurred in the form of  $1\frac{3}{4}$  for one and three quarters as contrasted with  $1\frac{3}{4}$ ), the error pattern for the teletype is highly different from that occurring with the electroluminescent. Of the 44 fraction errors with the teletype, 26 were committed by the selection of the denominator as the correct answer, whereas with the electroluminescent display, this happened only once. With this display the greatest error frequency of 14

involved the selection of the complete fractional part (e. g. 3/4 rather than 1 3/4); the second largest error frequency of 7 involved the selection of the whole number in combination with the numerator of the fraction, a type of error which explains how eleven "greater than" errors for the electroluminescent display can produce greater total mileage error than 32 for the teletype.

TABLE VI

Types of Errors in Reporting Visibility Mileage Involving Fractions

	<u>Teletype</u>	<u>Electroluminescent</u>
Denominator Only	26	1
Numerator Only	2	2
Whole Number and Numerator	1	7
Fractional Part of a Whole Number & Fraction	0	14
Other - inc Dk (Don't know)	15	9

To say that subtle figure/ground relationships have been operative to produce these differential response patterns in the reporting of fractions is to say nothing more than the obvious. The apparent explanation of this differential error pattern lies in the fact that a number of the fractions straddled the EL face plate across the 18th and 19th matrix positions.. Thus where the slash (/) in the fraction fell in the eighteenth matrix position there would probably be a greater tendency to reply with the whole number and numerator as the visibility mileage. If photographs had been taken of each electroluminescent display a more definitive explanation might be

warranted. It seems safe to say, however, that the multiple functions of the slash (/) in weather messages may be detrimental to accuracy of interpretation.

When the distribution of errors in responding to fractions is examined, it is found that 21% of the subjects making errors commit 71% of the errors, or alternately that 38% of the subjects making errors on fractions make 90% of the errors. Except for the Weather personnel, the concentration of errors among a minor percentage of subjects is greater for fractions than for errors in general as shown in Table IV. This provides additional evidence of the importance of identifying and taking some kind of corrective action where high error personnel are involved; a suggested procedure for accomplishing this purpose is set forth in section III C this report.

3. There remain for discussion those response classifications which exhibit substantially above average error rates as shown in Table VII. Mention has already been made of questions concerning barometric pressure tendency and amount and the ones on cloud types. Those to be discussed are (a) the Alpha classification of Visibility and Remarks, (b) the Alpha/Symbolic combinations, (c) the Numeric Visibility items, and (d) the Alpha/Numeric ones, all of which, with one exception, show above average rates for each of the subject groups.

a. Visibility and Remarks

With the exception of station identification letters, all response items which contained no symbolic or numeric characters, were classified here. There were a total of 20 questions for both displays

and, except for weather personnel, the error rates were high; 25% for GCA and 26.7% for pilots, rates which are almost 3 and 2 times respectively the average error rates for GCA and pilot personnel.

In searching for common elements among the questions one can say that over half the questions specifically asked about "visibility restriction" and most of the remaining involved elements such as precipitation, haze, smoke, and fog which are germane to visibility.

Only three of the twenty questions involved single letters within the weather message, i.e., two for haze (H) and one for rain (R). About two thirds of the items here classified came after the visibility mileage where about one third were found in the "Remarks." There is some evidence that a few questions were not properly understood, a matter which is discussed in more detail in "A Note on Scoring and the Questions" in Appendix B.

#### b. Alpha/Symbolic Classifications

Comment has already been made on the significant difference between the errors on the two displays for these responses. The pilot error rate for this class of items was double their overall average error rate; for GCA it was 1 1/3 times the average and for weather personnel 1 1/2 times the average. The items of concern here dealt, in the main, with visibility restrictions and variance in sky cover; they were composed of differential letter and symbol components, such as TRW+K and  $\oplus V \ominus$ , and apparently were not integrated with ease by the subjects. Since "relaxed criteria"

were used in scoring most of the items in this category (see

Note in Appendix B) the whole subject is worthy of some attention.

c. Numeric Visibility Items

The errors reflected in this classification are mainly those involved in the reading of fractions and when the errors concerned with reading of fractions are subtracted, the remainder of 11 errors for six questions involving "whole number" visibility mileage is comparatively inconsequential.

d. Alpha/Numeric Combinations

Here again we find quite substantial error rates ranging from almost double the average error rate for weather personnel to almost three times the average error rate for pilots. The remainder of the errors involving fractions are contained in these totals but comprise less than 14% of the total number of errors.

Most of the questions here again are ones dealing with visibility variation and a few on ceiling variation; typical correct responses were F1, D2, 2V2 1/2, 2400 V 2600, and 2 1/4 V.

In summary, it may be said that there exists a general weakness in replying to questions on visibility that is exhibited regardless of whether the information is Alpha only, Alpha/Symbolic, Numeric, or Alpha/Numeric. It is to be noted that this information may appear in various parts of the weather message rather than in a fixed position. With few exceptions multiple characters were involved with high error rates.

TABLE VII  
FREQUENCY TOTALS & PER CENT NOT CORRECT FOR BOTH DISPLAYS

	<u>FREQUENCIES</u>			ERROR RATE IN <u>PER CENT</u>		
	Wx N = 16	GCA N = 8	Pilots N = 18	Wx	GCA	Pilots
<u>ALPHA</u>						
Station Identification (50)	13	16	3	1.6	4.0	0.3
Visby & Remarks (20)	7	40	95	2.2	25.0	26.7
<u>SYMBOLIC</u>						
*Sky: a (11)	2	4	8	1.1	4.5	4.0
: b (46)	8	7	23	1.1	1.9	2.8
: c (34)	21	33	64	3.9	7.7	10.5
Wind Directions (15)	3	0	19	1.3	0.0	7.0
Alpha/ Symbolic (10)	6	10	36	3.8	12.5	20.0
<u>NUMERIC</u>						
Height of ceiling or cloud cover (10)	4	4	7	2.5	5.0	3.9
Temperature (14)	0	1	2	0.0	.9	.8
Dewpoint (14)	3	1	5	1.3	.9	2.0
Wind Speed (16)	6	2	6	2.3	1.6	2.1
Baro-Altimeter (17)	2	2	3	.7	1.5	1.0
Baro or Pressure tendency and amt. (4)	10	29	72	15.6	90.6	100.0
Visby (15)	9	22	35	3.8	18.3	13.0
Cloud types (3)	2	21	54	4.2	87.5	100.0
Alpha/ Numeric (21)	13	31	107	3.9	18.5	28.3
	(30.0)	109	223	539	2.3	9.3
<i>Fractions</i> (14)	11	27	39	4.9	24.1	15.5

\*For an explanation of Sky a, b, and c refer to note in Appendix B.

### C. Implications for Military Information Processing

The institution of such programs as "Zero Defects" would augur for the importance of facing up to the difficult question of what constitutes acceptable, or perhaps more appropriately, tolerable error in the processing of military information. Because of the small number of significant differences between the two displays, the liberty of summing the error frequencies and of showing the overall error rates has been taken in Table VII.

It should be borne in mind that subjects could look at the weather messages displayed while they were responding to the questions. It also should be borne in mind that weather airmen constitute a highly select group of airmen in general.\*

The data represented in Table VII are based upon 300 possible responses per individual subject. From the point of view of weather information processing the specific error rate data should be considered only as indicative rather than definitive for two reasons: (a) there were purposely a preponderant number of questions on sky cover in order to test the altered electro-luminescent symbology and hence there was not a balanced query of subjects concerning the various elements which constitute weather messages and (b) it is not known how representative the relatively small number of individual subjects in each group are of the populations from which they came.

It should be pointed out, though, that the weather message with its variety of manipulable Alpha, Symbolic, and Numeric

\*See AFM 50-5, Change C, Oct 65, Section V, Page 5-20-3, Para ABR 25231 (AFM means Air Force Manual)

data might well be used in a factorially designed experiment to produce some definitive conclusions on the subject of military information processing. Such an experiment should contain provisions to insure high motivation.

From this experiment, however, several things are quite clear:

1. The data definitely are indicative that certain individuals may be error prone. The preponderance of errors by a minority of the subjects as shown in Table IV as well as a correlation of .75 within subjects on errors made between the two displays are strong testimony. However, before the error prone concept can be considered as valid, it should be demonstrated that after a certain point in the training and/or experience of such subjects that no significant improvement can be effected in their performance through added training or experience.

2. For the processing of weather information, the employment of personnel of known proficiency or ability could be a relatively simple matter. It is suggested that a standard set of weather messages of increasing difficulty and complexity be developed. These weather messages could be administered in standardized fashion to weather personnel (and to GCA, navigator and pilot personnel if desired) in both sufficient and representative numbers to secure normative data on time and errors for the various groups. With such information at hand the relative proficiency of a given individual or individuals could easily be determined whenever desired.

3. A logical extension of the proposal above leads to the question - among the spectrum of military information systems, how many lend themselves to such relatively simple procedures for insuring that they can be manned with personnel of known proficiency?

## APPENDIX A

Weather Messages Displayed by Teletype

Weather Messages Displayed by Electroluminescence

Response Sheets with Questions

Photographs of Alpha, Numeric, and Symbolic Characters Used on  
the Electroluminescent Display (Courtesy Sylvania Electric Products,  
Inc.)

Instructions to Subjects

- \* The typewriter used to prepare both groups of weather messages for this report had no slash on the zero; however both the teletype and electroluminescent messages as actually displayed to the subject did have a slash across the zero.

TELETYPE DISPLAYED WEATHER MESSAGES

1. BED 07 73/68C/986
2. FOK OSHK 71/69→ 6/986
3. CAR 8006HK 68/66→ 8/984
4. POU 450M7509 68/59→ 14/983/0V0
5. MGW -XM3007002BD 69/65→ 15+30/978/D3 VSBY E7
6. AKR M250850120010 75/69→ 10/978/VIRGA NW-N
7. RAN M3009001500200010 69/65→ 6/986/CB OVHD FQT LTGIC N
8. HAR M250900150025002TRW 73/68→ 10+20/985/T OVHD MOVG E AB35E55
9. PSM M250800200011/4TRW+ 73/71→ 10+30/985/T NE OCNL LTGIC N-E
10. PLN -X200500M150013/4VRF 40/28→ 3/998/F1 VSBY 11/2V2 OCNL SW --
11. YIP M450/010TORNADOW RW -70/69→ 30/982/UNCONFIRMED TORNADO 5W BED 1600 E
12. MRB M350/09WATERSPOUT S 69/M→ 10+25/985/WATERSPOUT S B25 RW-OVR RDGE
13. COF O10 73/70→ 4/985
14. BUF 90010 70/69→ 5/986
15. MPV M8005BD 67/65→ 11/987
16. BHL M4007006BD 69/67→ 15+20/982
17. SAW -XM4007002FK 66/65→ 14/995/F1 VSBY NE 7
18. BLX 300M75012006HK 75/74→ 4/988/CB NW MOVG NE
19. HVN 300M850150025007RW 69/68→ 10+20/985/CB OVHD FQT LTGIC NW-NE
20. GRL M250900150013/4TRW+K 73/70→ 10+20/998/T W MOVG E FQT LTGCC N
21. AYE M29V090-0200011/4BD 75/45→ 30/986/CIG 28V30 DUST DEVILS NW
22. LEX -XM25V01500/01/2RF 125/33/31→ 4/986/F1 CIG 23V27/11500 1727 22
23. TYS -XM25V01500/011/4SFH 35/34→ 9/988/F1G1G 23V27 S OCNLY S- WET SNW
24. BGM 30050-0M15005H 28/27→ 5/986/CONTRAILS SNW SHWRS S PATCH GF W
25. SWF 35-070-0150-0/-05H 60/59→ 10+15/998/K DRFTG OVR RNWY 11 K LYR S-N

ELECTROLUMINESCENT DISPLAYED WEATHER MESSAGES

1. QB 08 74/69 C/985
2. ACK 06HD 70/45+ 6/986
3. HUL 8505BD 67/66+ 10/984
4. INR 400M6008 70/65+ 15/984/0V0
5. NEL -XM3507501BD 65/60+ 12+40/984/D2 VSBY W8
6. MSS 250M850100012 69/54+ 9/986/ VIRGA N-NE
7. ZZV 250M8001000250012 71/70+ 6/983/CB OVHD FQT LTGCC W
8. AOO M350900200011/4TRW+ 74/69+ 10+25/986/T N-NE MOVG E AB10E50
9. PWM M300900200013/4TRW- 74/70+ 15+25/987/T N-E OCNL LTGICCC NE-E
10. APN -X300M500150021/4VFK 38/26+ 2/989/F1 VSBY 2V21/2 INTMT R-
11. HAT M4508FUNNEL CLOUD NNW71/68+ 20+35/981/FUNNEL CLOUD NNW MOVG NEWD B34
12. LEB 5025050070-0A9002FH 70/MC /983/HIR CLDS VSBL SFC VSBY 9/115 1487
13. CEF 06H 72/69+ 5/986
14. PHL 85010 69/65+ 6/985
15. HAT M7506HK 67/66+ 12/983
16. ART M3507005HK 68/65+ 12+15/985
17. DET -XM3008005BD 54/51+ 20/987/D1 VIRGA NW
18. BDR 200M80012005KH 70/68+ 5/985/CB SW MOVG NE
19. CLE 250M600100025006SW 40/35+ 10+15/992/CB N MOVG E FQT LTGCC N
20. SGV M300900150011/2TRW-K 75/70+ 10+23/986/T N MOVG E FQT LTGIC E
21. JXN M25V080-0250-021/2H 76/65+ 10/999/CIG 24V26 VSBY NE13/4SE1
22. QR -X20M300900/01/2VF 225/34/30+ 10/987/F1 VSBY 0V1/12001 1577 22
23. BKL -XM250150011/2VR 233/33/30+ 9/996/F1 CONTRAILS VSBY 1V2/113 1780
24. BAL -XM30050-0/04F 32/29+ 2/985/F3 INTMT ZR- OCNL S- PATCH GF NW
25. BAF 40-080-0M150025007 59/40+ 4/995/VIRGA NW GF BANK N WND DRCTN VRBL

TT Display

DISPLAY #1

1. What are the station identification letters?
2. What is the sky cover?
3. What is the temperature?
4. What is the dewpoint?
5. What is the altimeter setting?
6. What is the visibility?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

DISPLAY #2

1. What are the station identification letters?
2. What is the sky cover?
3. What is the temperature?
4. What is the dewpoint?
5. What is the wind direction?
6. What is the wind speed?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

DISPLAY #3

1. What are the station identification letters?
2. What sky cover is reported at 8000'?
3. What is the visibility restriction?
4. What is the wind direction?
5. What is the wind speed?
6. What is the altimeter setting?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

DISPLAY #4

1. What are the station identification letters?
2. Give the sky cover for the 1st layer of clouds?
3. Give the height of the ceiling?
4. Give the sky cover for the 2nd layer of clouds?
5. What is the altimeter setting?
6. How is the sky cover varying?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

#### DISPLAY #5

1. What are the station identification letters?
2. What sky cover is reported at 3000'?
3. What sky cover is reported at 7000'?
4. What is the dewpoint?
5. What is causing the partial obscuration?
6. What are the remarks concerning visibility?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

#### DISPLAY #6

1. What are the station identification letters?
2. What is the sky cover of the 1st layer of clouds?
3. What is the sky cover of the 2nd layer of clouds?
4. What is the sky cover of the 3rd layer of clouds?
5. What is the wind direction?
6. What is the wind speed?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

#### DISPLAY #7

1. What are the station identification letters?
2. What is the sky cover at 9000'?
3. What is the height of the 1st broken layer of clouds?
4. What is the sky cover at 15,000'?
5. What is the sky cover at 20,000'?
6. What is the altimeter setting?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

#### DISPLAY #8

1. What are the station identification letters?
2. What is the sky cover at 2500'?
3. What is the sky cover at 9000'?
4. What is the sky cover at 15,000'?
5. What is the visibility?
6. What is the restriction to visibility?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

#### DISPLAY #9

1. What are the station identification letters?
2. What is the sky cover of the 1st layer of clouds?
3. What is the sky cover reported at 8000'?
4. What is the sky cover at 20,000'?
5. What is the visibility?
6. What is the restriction to visibility?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

#### DISPLAY #10

1. What are the station identification letters?
2. What is the visibility?
3. What is the restriction to visibility?
4. What is the dewpoint?
5. What is causing the partial obscuration?
6. How variable is the visibility?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

#### DISPLAY #11

1. What are the station identification letters?
2. What is the sky cover at the 1st layer of clouds?
3. What is the wind direction?
4. What is the wind speed?
5. What is the temperature?
6. What is the dewpoint?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

#### DISPLAY #12

1. What are the station identification letters?
2. What is the sky cover at 3500'?
3. What is the sky cover of the top layer?
4. What is the wind speed?
5. What is the altimeter setting?
6. Are there rainshowers near the station?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

#### DISPLAY #13

1. What are the station identification letters?
2. What is the sky cover?
3. What is the wind direction?
4. What is the wind speed?
5. What is the altimeter setting?
6. What is the temperature?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

#### DISPLAY #14

1. What are the station identification letters?
2. What is the height of the 1st layer of clouds?
3. What is the sky cover?
4. What is the temperature?
5. What is the dewpoint?
6. What is the altimeter setting?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

#### DISPLAY #15

1. What are the station identification letters?
2. What is the height of the 1st sky cover?
3. What is the sky cover?
4. What is the temperature?
5. What is the dewpoint?
6. What is the altimeter setting?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

#### DISPLAY #16

1. What are the station identification letters?
2. What is the sky cover at 4000'?
3. What is the sky cover at 7000'?
4. What is the wind direction?
5. What is the wind speed?
6. What is the restriction to visibility?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

DISPLAY #17

1. What are the station identification letters?
2. What is the sky cover at 4000'?
3. What is the sky cover at 7000'?
4. What is the visibility?
5. What is the present weather?
6. What is causing the partial obscuration?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

DISPLAY #18

1. What are the station identification letters?
2. At what height is the 1st layer of clouds reported?
3. What is the sky cover of the 1st layer of clouds?
4. What sky cover is reported at 7500'?
5. What sky cover is reported at 12,000'?
6. What is the temperature?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

DISPLAY #19

1. What are the station identification letters?
2. What is the sky cover of the first layer of clouds?
3. What is the sky cover of the 2nd layer of clouds?
4. What is the sky cover of the 3rd layer of clouds?
5. What is the sky cover for the 4th layer of clouds?
6. What is the visibility?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

DISPLAY #20

1. What are the station identification letters?
2. What is the sky cover for the first layer of clouds?
3. What is the sky cover for the 2nd layer of clouds?
4. What is the sky cover for the 3rd layer of clouds?
5. What are the restrictions to visibility?
6. What is the visibility?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

#### DISPLAY #21

1. What are the station identification letters? 1. \_\_\_\_\_
2. What is the sky cover at 2900' ? 2. \_\_\_\_\_
3. What is the sky cover at 9000' ? 3. \_\_\_\_\_
4. What is the sky cover at 20,000' ? 4. \_\_\_\_\_
5. Does the ceiling vary and if so, between what altitudes? 5. \_\_\_\_\_
6. What is the obstruction to visibility in the N.W. quadrant? 6. \_\_\_\_\_

#### DISPLAY #22

1. What are the station identification letters? 1. \_\_\_\_\_
2. What is the sky cover of the top layer of clouds? 2. \_\_\_\_\_
3. What is the barometric tendency and amount? 3. \_\_\_\_\_
4. How is the ceiling varying? 4. \_\_\_\_\_
5. What are the cloud types? 5. \_\_\_\_\_
6. What is the visibility? 6. \_\_\_\_\_

#### DISPLAY #23

1. What are the station identification letters? 1. \_\_\_\_\_
2. What is the sky cover at 15,000' ? 2. \_\_\_\_\_
3. What is the visibility? 3. \_\_\_\_\_
4. What is the restriction to visibility? 4. \_\_\_\_\_
5. How does the ceiling vary? 5. \_\_\_\_\_
6. What are the remarks concerning precipitation? 6. \_\_\_\_\_

#### DISPLAY #24

1. What are the station identification letters? 1. \_\_\_\_\_
2. What is the sky cover of the top layer of clouds? 2. \_\_\_\_\_
3. What is the wind direction? 3. \_\_\_\_\_
4. What is the wind speed? 4. \_\_\_\_\_
5. What are the remarks concerning precipitation? 5. \_\_\_\_\_
6. What is the altimeter setting? 6. \_\_\_\_\_

DISPLAY #25

- |   |          |
|---|----------|
| 1. What are the station identification letters? | 1. _____ |
| 2. What is the sky cover at 15,000'?            | 2. _____ |
| 3. What is the wind speed?                      | 3. _____ |
| 4. What is the local obstruction to vision?     | 4. _____ |
| 5. What is the wind direction?                  | 5. _____ |
| 6. What are the quadrants of the smoke layer?   | 6. _____ |

## EL DISPLAY

### DISPLAY #1

1. What are the station identification letters?
2. What is the sky cover?
3. What is the temperature?
4. What is the dewpoint?
5. What is the altimeter setting?
6. What is the visibility?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

### DISPLAY #2

1. What are the station identification letters?
2. What is the sky cover?
3. What is the temperature?
4. What is the dewpoint?
5. What is the wind direction?
6. What is the wind speed?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

### DISPLAY #3

1. What are the station identification letters?
2. What sky cover is reported at 8500'?
3. What is the visibility restriction?
4. What is the wind direction?
5. What is the wind speed?
6. What is the altimeter setting?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

### DISPLAY #4

1. What are the station identification letters?
2. Give the sky cover of the 1st layer of clouds?
3. Give the height of the ceiling?
4. Give the sky cover for the 2nd layer of clouds?
5. What is the altimeter setting?
6. How is the sky cover varying?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

#### DISPLAY #5

1. What are the station identification letters?
2. What sky cover is reported at 3500'?
3. What sky cover is reported at 7500'?
4. What is the dewpoint temperature?
5. What is causing the partial obscuration?
6. What are the remarks concerning visibility?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

#### DISPLAY #6

1. What are the station identification letters?
2. What is the sky cover of the 1st layer of clouds?
3. What is the sky cover of the 2nd layer of clouds?
4. What is the sky cover of the 3rd layer of clouds?
5. What is the wind direction?
6. What is the wind speed?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

#### DISPLAY #7

1. What are the station identification letters?
2. What is the sky cover at 2500'?
3. What is the height of the 1st broken layer of clouds?
4. What is the sky cover at 10,000'?
5. What is the sky cover at 25,000'?
6. What is the altimeter setting?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

#### DISPLAY #8

1. What are the station identification letters?
2. What is the sky cover at 3500'?
3. What is the sky cover at 9000'?
4. What is the sky cover at 20,000'?
5. What is the visibility?
6. What is the restriction to visibility?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

#### DISPLAY #9

1. What are the station identification letters?
2. What is the sky cover of the 1st layer of clouds?
3. What is the sky cover reported at 9000'?
4. What is the sky cover at 20,000'?
5. What is the visibility?
6. What is the restriction to visibility?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

#### DISPLAY #10

1. What are the station identification letters?
2. What is the visibility?
3. What is the restriction to visibility?
4. What is the dewpoint?
5. What is causing the partial obscuration?
6. How variable is the visibility?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

#### DISPLAY #11

1. What are the station identification letters?
2. What is the sky cover?
3. What is the wind direction?
4. What is the wind speed?
5. What is the temperature?
6. What is the dewpoint?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

#### DISPLAY #12

1. What are the station identification letters?
2. What is the sky cover at 500'?
3. What is the sky cover at 2500'?
4. What is the sky cover at 5000'?
5. What is the barometric tendency and pressure change?
6. What are the cloud types reported?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

#### DISPLAY #13

1. What are the station identification letters?
2. What is the sky cover?
3. What is the wind direction?
4. What is the wind speed?
5. What is the restriction to visibility?
6. What is the temperature?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

#### DISPLAY #14

1. What are the station identification letters?
2. What is the height of the 1st layer of clouds?
3. What is the sky cover?
4. What is the temperature?
5. What is the dewpoint?
6. What is the altimeter setting?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

#### DISPLAY #15

1. What are the station identification letters?
2. At what altitude is the first sky cover found at?
3. What is the sky cover?
4. What is the temperature?
5. What is the dewpoint?
6. What is the altimeter setting?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

#### DISPLAY #16

1. What are the station identification letters?
2. What is the sky cover at 3500'?
3. What is the sky cover at 7000'?
4. What is the wind direction?
5. What is the wind speed?
6. What is the restriction to visibility?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

#### DISPLAY #17

1. What are the station identification letters?
2. What is the sky cover at 3000'?
3. What is the sky cover at 8000'?
4. What is the visibility?
5. What is the present weather?
6. What is causing the partial obscuration?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

#### DISPLAY #18

1. What are the station identification letters?
2. At what height is the 1st layer of clouds reported?
3. What is the sky cover of the 1st layer of clouds?
4. What sky cover is reported at 8000'?
5. What sky cover is reported at 12,000'?
6. What is the temperature?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

#### DISPLAY #19

1. What are the station identification letters?
2. What is the sky cover of the 1st layer of clouds?
3. What is the sky cover of the 2nd layer of clouds?
4. What is the sky cover of the 3rd layer of clouds?
5. What is the sky cover of the 4th layer of clouds?
6. What is the visibility?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

#### DISPLAY #20

1. What are the station identification letters?
2. What is the sky cover for the 1st layer of clouds?
3. What is the sky cover for the 2nd layer of clouds?
4. What is the sky cover for the 3rd layer of clouds?
5. What are the restrictions to visibility?
6. What is the visibility?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

#### DISPLAY #21

1. What are the station identification letters? 1. \_\_\_\_\_
2. What is the sky cover at 2500' ? 2. \_\_\_\_\_
3. What is the sky cover at 8000' ? 3. \_\_\_\_\_
4. What is the sky cover at 25,000' ? 4. \_\_\_\_\_
5. Does the ceiling vary and if so, between what altitudes? 5. \_\_\_\_\_
6. What is the prevailing visibility in the NE quadrant? 6. \_\_\_\_\_

#### DISPLAY #22

1. What are the station identification letters? 1. \_\_\_\_\_
2. What is the sky cover of the top layer of clouds? 2. \_\_\_\_\_
3. What is the barometric tendency and amount? 3. \_\_\_\_\_
4. How is the visibility varying? 4. \_\_\_\_\_
5. What are the cloud types? 5. \_\_\_\_\_
6. What is the visibility? 6. \_\_\_\_\_

#### DISPLAY #23

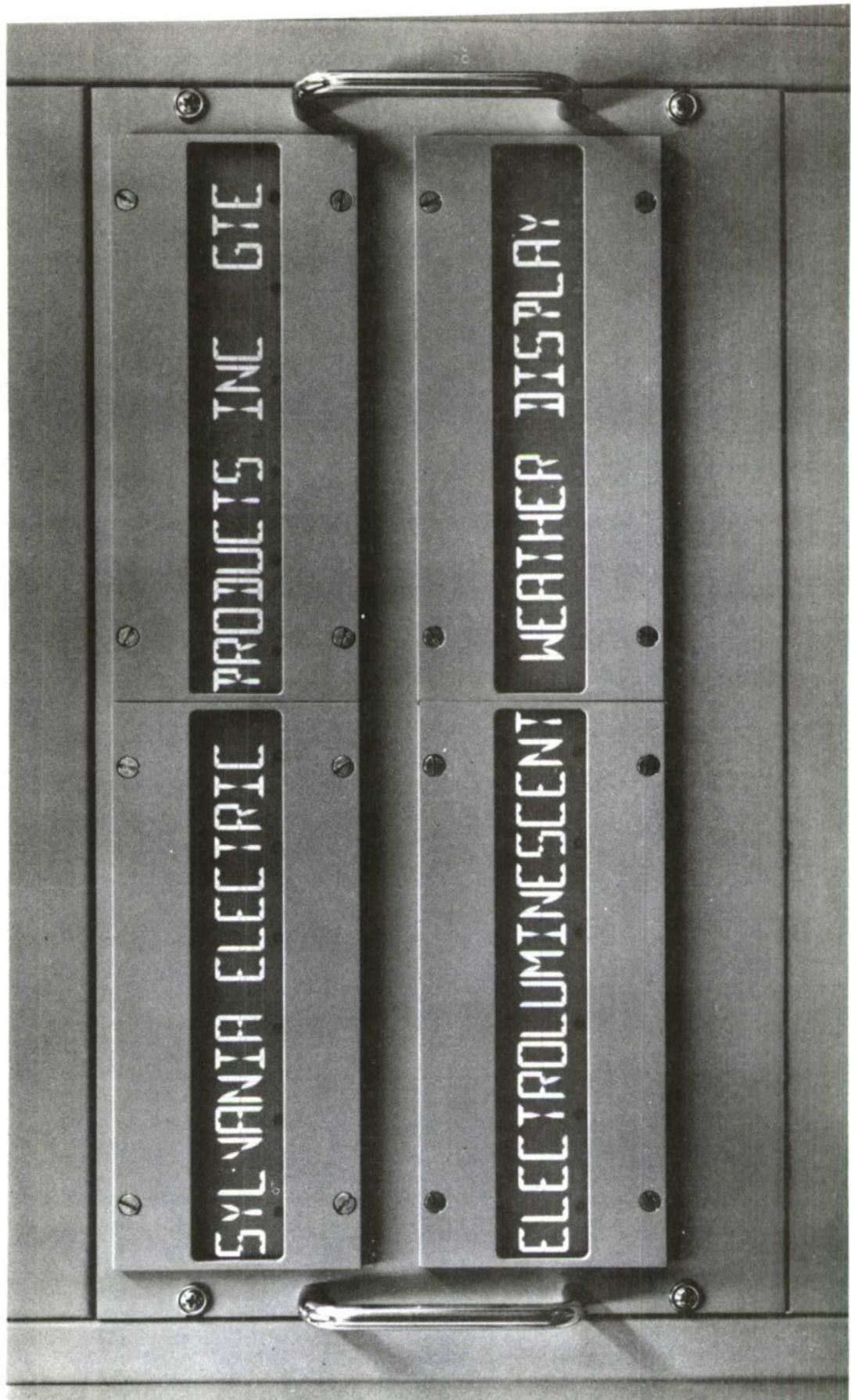
1. What are the station identification letters? 1. \_\_\_\_\_
2. What is the sky cover at 15,000' ? 2. \_\_\_\_\_
3. What is the visibility? 3. \_\_\_\_\_
4. What is the restriction to visibility? 4. \_\_\_\_\_
5. What are the remarks concerning visibility? 5. \_\_\_\_\_
6. What is the pressure tendency and amount change? 6. \_\_\_\_\_

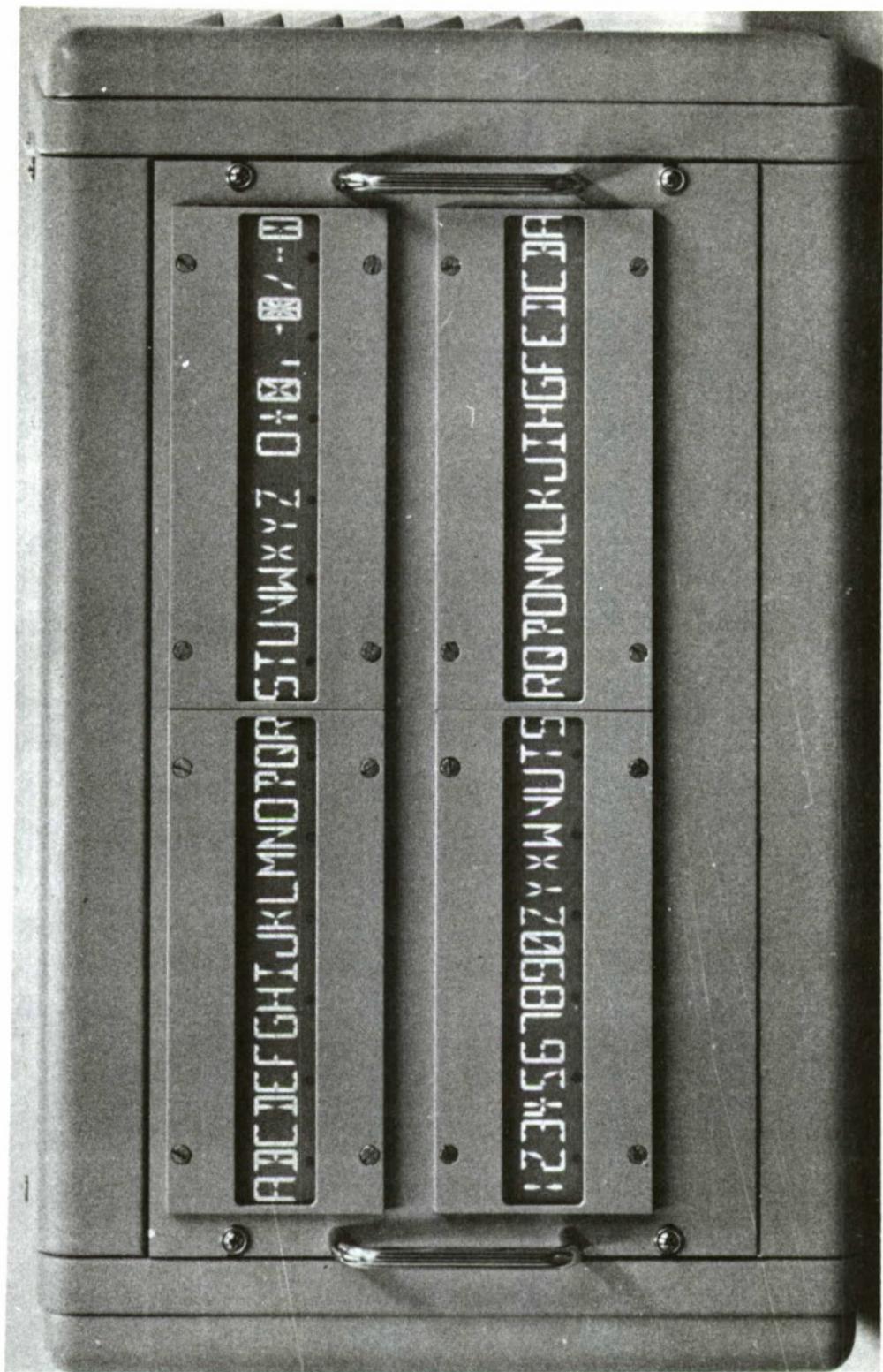
#### DISPLAY #24

1. What are the station identification letters? 1. \_\_\_\_\_
2. What is the sky cover of the top layer of clouds? 2. \_\_\_\_\_
3. What is the wind direction? 3. \_\_\_\_\_
4. What is the wind speed? 4. \_\_\_\_\_
5. What is causing the partial obscuration? 5. \_\_\_\_\_
6. What is the altimeter setting? 6. \_\_\_\_\_

**DISPLAY #25**

- |  |          |
|--|----------|
| 1. What are the station identification letters?        | 1. _____ |
| 2. What is the sky cover at 25,000'?                   | 2. _____ |
| 3. What are the remarks concerning precipitation?      | 3. _____ |
| 4. What are the remarks concerning fog?                | 4. _____ |
| 5. What are the remarks concerning the wind direction? | 5. _____ |
| 6. What is the altimeter setting?                      | 6. _____ |





### Instructions to Subjects

We appreciate your coming up to help us very much. This exercise involves reading 25 weather messages on teletype and 25 on this electroluminescent display and recording your answers to questions for each message.

We would like you to read these as you would any normal weather message in a situation where the information is needed by you. There are six questions for each message.

You are to start each message by throwing the switch toward the ON position. As soon as you have read the message and recorded your answers, you are to throw the switch back to its original position. The red light is a signal to you that you can start when you're ready. Only throw the switch when the red light is on.

You should read the questions pertaining to each display first. Also, (for the electroluminescent) you should consider that the message is a single straight line.

Do you have any questions?

## APPENDIX B

Response Times in Minutes and Errors by Subjects and Display Type

Errors on Electroluminescent in Station Identification

Errors on Teletype in Station Identification

Remarks Summary

Note on Scoring and the Questions

## Appendix B

### Response Times in Minutes and Errors by Subjects and Display Type

<u>Subject #</u>	<u>Time</u>		<u>Errors</u>	
<u>Weather</u>	<u>TT</u>	<u>EL</u>	<u>TT</u>	<u>EL</u>
1	10.2	16.8	4	14
2	10.6	12.1	1	3
3	8.8	10.2	2	5
4	7.8	9.2	3	5
5	10.2	9.8	3	0
6	10.7	10.7	3	3
7	11.0	12.6	14	2
8	12.4	11.4	1	3
9	7.5	10.1	0	0
10	9.7	14.1	3	5
11	12.2	11.3	4	5
12	12.8	15.3	0	1
13	10.0	10.5	0	5
14	11.6	10.9	4	3
39	8.7	11.4	2	6
41	11.7	10.8	2	3
<u>GCA</u>				
15	14.5	19.3	6	17
16	11.4	16.3	3	12
17	23.5	15.9	7	7
18	19.7	14.5	20	27
19	16.0	18.2	21	31
20	21.6	15.5	13	8
21	15.2	13.9	8	10
22	32.9	41.3	11	22

<u>Pilots</u>	<u>Time</u>		<u>Errors</u>	
	<u>TT</u>	<u>EL</u>	<u>TT</u>	<u>EL</u>
23	20.8	15.4	19	23
24	16.3	27.1	20	22
25	15.4	23.0	9	11
26	16.9	12.6	11	9
27	15.4	15.3	10	15
28	17.9	30.9	9	16
29	16.1	15.1	8	10
30	15.8	22.3	9	10
31	13.7	21.1	9	16
32	20.3	23.7	10	10
33	13.9	14.0	11	10
34	15.3	18.9	8	9
35	23.8	21.3	9	9
36	15.3	27.8	11	25
37	20.6	15.2	27	19
38	13.7	17.4	28	20
40	16.4	14.3	34	21
42	21.1	16.6	23	19

Appendix B  
Errors on Electroluminescent in Station Identification

Erroneous Responses

<u>Station Identification Presented</u>	<u>Weathermen</u>	<u>GCA</u>	<u>Pilots</u>
AOO		ADO	ROD
ART			AKT
BAF		DAF (2)	
BAL		DAL (2)	
BDR		DDR	
BKL		DKL (2)	
CLE		CIE	
HAT	HRT (2)		
LEB	LED (2)		
PWM	AWM		
QB	QD	OB (2) QD (2) Dk	Dk
SGV		EGV SGN	
A for P	1	K for R	1
D for B	12	N for V	1
D for O	2	O for Q	2
E for S	1	R for A	2
I for L	1	Dk for QB	2

Appendix B  
Errors on Teletype in Station Identification

<u>Station Identification Presented</u>	<u>Weathermen</u>	<u>GCA</u>	<u>Pilots</u>
AKR	HKR		
BGM	BGN		
BLX	BLK BIX		
FOK	FOR		
MGW	MCW		
RAN	RAW		
C for G 1			
H for A 1			
I for L 1			
K for X 1			
N for M 1			
R for K 1			
W for N 1			

## Appendix B

<u>Remarks Summary</u>	<u>Frequency</u>
Cloud symbols confusing	2
V confusing	6
Division of display into two lines distracting	4
Wind arrows too small	4
Z and 2 confusing - should add horizontal bar thru center of Z	3
8 difficult to recognize	2
S and 5 confused	4
B and D confused	1
l difficult to recognize	1
Clear and zero gave trouble	3
Spacing too close - especially on cloud symbols	2
Diagonal marks confusing	2
No trouble anticipated after practice	5
Wind arrow positions should be changed so for example, North wind is shown as follows 	1

## Appendix B

### Note on Scoring and the Questions

(1) The error scoring set forth in this report reflects the not-correct responses; thus included, are responses scored as erroneous, responses of "Don't know" and omitted responses, the last named having also been reported as "Dk".

It should be pointed out that this report does not contain maximumly obtainable error rates because subjects were not specifically instructed to make their responses as specific as possible in terms of the information contained in the weather messages presented. For example, Question 3.3 for the electroluminescent asks "What is the visibility restriction" with the most complete answer being "blowing dust;" if the subject responded "dust" it was not scored as an error. Similarly, for Questions 5.5 on both displays, "What is causing the partial obscuration;" depending upon the display the most specific answers were "dust 2/10ths or 3/10ths;" however, if the subject merely responded "dust" it was not scored as erroneous. Again, question 8.6 on the electroluminescent, calls for the response "Thunder, heavy rain showers and smoke (TRW+ K);" if the subject responded with three of the four underscored elements, the response was not scored as erroneous.

It should be apparent that if a response criterion of specificity equivalent to that of the message is required something very close to 100% objectivity in scoring may be achieved. In the present study about 90% of the questions were scored on a strictly objective

basis, whereas in about 10%, specific scoring criteria had to be determined for each question.

(2) Almost 50 years ago Muscio, in the British Journal of Psychology (1916) called attention to the influence of the form of the question upon the response. Since the initial purpose of this experiment was comparative and the same types of questions were being used for both displays, the only pre-testing of questions and procedures conducted was with knowledgeable weather personnel. What Muscio was talking about is particularly evident in the error rates for the questions on sky cover which involved symbolic displays. Three different kinds of questions were addressed to the subjects (a) What is the sky cover? (b) What is the sky cover at \_\_\_\_\_ ft. ? and (c) What is the sky cover of the (1st, 2nd, 3rd or 4th) layer of clouds? Table VII shows that the last form of the question contributed substantially higher error rates than the first two forms of the questions. Question 17.5 for both displays asked "What is the present weather?" The requisite responses for the teletype and electroluminescent were "blowing dust" (BD), and fog and smoke (FK) respectively. When questions requiring identical responses (Teletype 3.3 and 10.3) were asked the error rates were much less, particularly for GCA and pilot personnel. If a factorial experiment is to be designed to conduct some basic research with weather information processing, there should be rigorous pre-testing of the questions employed.

## Appendix C

### Detailed Erroneous Responses by Display Type and Subject Group

Parentheses have been used in two ways in the following pages:

- (1) to bracket responses which had to be typed on more than one line,
- and (2) to encase numerals which specify incorrect response frequencies in the last three columns.

TELETYPE MESSAGES

QUESTION	# OF ERRORS	CORRECT RESPONSES	Wx	INCORRECT RESPONSES	PILOTS
			GCA		
1.2	1	clear			overcast 76
1.4	1	68			
1.5	1	2986			
1.6	2	7 mi.			unlimited C
2.1	1	FOR			
2.2	2	clear			
2.3	1		71°		500 overcast Dk
2.4	1		69°		
2.5	2		WW		
3.2	2	scattered			
3.3	2	breeze and smoke	6		
3.4	2	WW			
4.2	6	scattered	45 (2)		
4.3	2		7500		
4.4	2			broken (broken variable to scattered)	no ceiling 7500 (2)
4.6	3				decreasing (variable scattered) (overcast variable to scattered)

TELETYPE WEATHER MESSAGES

QUESTION	# OF ERRORS	CORRECT RESPONSES		INCORRECT RESPONSES		PILOTS
		Wx	GCA	Wx	GCA	
5.1	1	MCH				
5.2	2	broken		Dk		obscured
5.3	1	overcast		Dk		
5.4	3	65		69 (2)		
5.5	4	dust 3/10		Dk		smoke Dk (2)
5.6	5	(East quad. 7 miles)		estimated 7		estimated 7 est 7 (2) Vis est 7
6.1	1	AIR		HCR		
6.2	3	broken			25	2500 (2)
6.3	3	broken			85	12000
6.4	4	overcast			120	8500
6.5	2	WW		RAN		1200; 8500 broken ESE (2)
7.1	1			3000		
7.2	3				overcast	
8.3	1					(scattered broken)
8.4	1					(scattered broken)
8.5	1					10
8.6	6	2 miles thunder showers				Dk (4)
		(Hail mov East)				trace rain

TELETYPE WEATHER MESSAGES

QUESTION	# OF ERRORS	CORRECT RESPONSES	Wx	INCORRECT RESPONSES QCA	PILOTS
9.2	1	broken			2500
9.5	8	1 1/4 miles	Dk 4 (3)	1 1/2 4 (2)	
9.6	5	(thunder and heavy showers)		10 (rain showers) (2) rain	
				Temp Rain SHO light rain	
10.2	6	1 3/4 variable	1 1/4 1/4	4 Dk 3 Dk (4)	4
10.3	8	rain and fog		(OCNL very light snow showers)	Dk (4) (partially obscured)
10.5	15	fog 1/10		Dk (light snow showers)	snow Dk (4)
				(very light snow showers)	(very light snow showers)
10.6	7	(1 1/2 variable to 2 mi.)	Dk (2)	(occasional snow showers)	(occasional snow showers) (2)
				snow showers	snow showers
				light showers	light showers
				CV	CV
				2 1/2 mi. varying 2 miles	2 1/2 mi. varying 2 miles
				Dk (2)	Dk (2)
					1

TELETYPE WEATHER MESSAGES

QUESTION	# OF ERRORS	CORRECT RESPONSES	Wx	INCORRECT RESPONSES	PILOTS
11.2	3	broken		4500 (2) (4500 broken to overcast)	
11.3	2	WW		SE	
11.4	2	30	3	40°	69
11.5	2	70°		28	70
11.6	2	69			(broken to overcast) (4)
12.2	4	broken		3500 (3) (broken to overcast) (4)	
12.3	10	overcast	Dk	35	high Dk
12.4	4	10 + 25	25	10 gust	
12.5	1	2985	W	2982	
12.6	8	(yes or over ridge)	no	no (2) Dk	no (2) over head out range
13.3	2	West			East
13.4	1	4			E4
13.5	1	2985			light
14.2	2	9000	scattered	2885	
14.3	1	scattered			broken

TELETYPE WEATHER MESSAGES

QUESTION	# OF ERRORS	CORRECT RESPONSES		INCORRECT RESPONSES		PILOTS
		Wx	GCA	Wx	GCA	
15.2	1	8000 NW		broken		
16.4	2					SE SW
16.5	1	15 + 20 blowing dust		15	Dk (5)	147 to NE Dk (5)
16.6	3				-x	(thin obscured) 4000 broken)
17.4	1	2 miles fog and smoke		none	1 FR	(partially obscured) (5)
17.5	24					all above obscured (2)
						lousy overcast smoke haze
17.6	3			fog 1/10	K	
18.1	2			BLX	BLX BIX 40	
18.2	2	3000				S
18.3	1	scattered				B
18.5	1	broken		OVR		
19.2	2	scattered			30	3000
19.3	2	broken			85	8500
19.4	2	broken			150	1500
19.5	2	overcast			250	2500
19.6	1	7 miles				10-20

## TELETYPE WEATHER MESSAGES

QUESTION	# OF ERRORS	CORRECT RESPONSES	WX	INCORRECT RESPONSES GCA	PILOTS
20.2	2	broken		25	2500
20.3	2	broken		90	9000
20.4	2	overcast		150	15000
20.5	10	(heavy thunder- showers and smoke )	K (rain shower and smoke)	smoke (2) (thunder- storms W moving East)	smoke (2) haze rainshowers (2) 1 HVR rain show
20.6	11	1 3/4 miles	Dk 4 (4)	10-20 4 (5)	scattered
21.3	1	thin broken	29-200	no	
21.5	9	2800 to 3000	2900-20000	2900 to 9000 (2)	
				2900	
				9000	
				29-90	
			Dk	Dk	
22.2	4	overcast		15000 (3)	
22.3	28	115	-00 (2) 1	Dk (5) 125 2986 1012.5	broken Dk (10) 2986/FI 2986 falling 1012.5 falling
				125	falling 1 (2)
				2986	2986 falling

TELETYPE WEATHER MESSAGES

QUESTION	# OF ERRORS	CORRECT RESPONSES	INCORRECT RESPONSES		
			Wx	GCA	PILOTS
22.4	9	2300-2700!	(broken to overcast) (2)	(thin obscured to overcast)	Dk
			variable broken 2500 to 15000 (broken to overcast) (obscured to broken)		
22.5	27	727 or SF, AS, CS	(st, none none) Dk	Dk (6) (broken to overcast)	RF Dk (12) low stratos fog stratos rain to fog
				2	2 (3)
22.6	6	1/2 mi.		Dk	
23.2	8	broken		2	(broken to overcast) (2)
23.3	6	1 1/4 mi.		4	(broken to overcast) (5)
23.4	4	snow, fog, haze	H	LLV Bl 4 4	thin overcast 4 (3)
			Dk	Dk	fog

TELETYPE WEATHER MESSAGES

QUESTION	# OF ERRORS	CORRECT RESPONSES	Wx	INCORRECT RESPONSES	GCA	PILOTS
23.5	8	2300 to 2700		Dk (3) 2500 to 15000 variable broken broken OCNY (thin obscured to broken) (south to NW quad)		
23.6	16	( moderate snow occasional light snow wet snow)		OCNLS-(2) (occ. lt. snow) (2) Dk S- wet snow		
					variable light wet snow (3) occ lt. snow (2) lgt snow (occasional lt. snow NW)	
24.1	1	BGM				
24.2	3	broken				
24.3	2	overcast				
24.4	1	West				
24.5	3	5 miles				
		(snow showers to the south)				
25.2	1	Dk				
		Shwrs				
		Shwrs				
25.4	13	thin broken				
25.5	1	haze				
25.6	2	West				
		South to North				
		SE to NE				

ELECTROLUMINESCENT DISPLAY WEATHER MESSAGES

QUESTION	# OF ERRORS	CORRECT RESPONSES	INCORRECT RESPONSES			PILOTS
			Wx	GCA	Dk	
1.1	7	QB	QD	OB (2) QD (2)	Dk	
1.2	2	clear 29.85 8 miles	2998	Dk (2)	2998 (2) unlimited	
1.5	3		Dk		15	4
1.6	6			clear (2)	5	
2.2	2	clear north	scattered	haze	south	
2.5	1					
3.2	2	scattered blowing dust SW	broken Dk (2)	broken 5 (2)		
3.3	4					NE
3.4	2				5	
3.5	2	10 miles				
4.2	10	scattered	4000	Dk	4000 (5)	
4.3	2			4000		
4.4	14	broken		Dk (2)	4000 6000 (3)	
4.6	5	broken variable to scattered	6000 (2) overcast (2) (scattered v broken)	6000 (2) overcast	Dk (2) (overcast v broken)	100 F

ELECTROLUMINESCENT DISPLAY WEATHER MESSAGES

QUESTION	# OF ERRORS	CORRECT RESPONSES	Wx	INCORRECT RESPONSES	PILOTS
5.2	1	broken		(partly obscured)	
5.4	1	60°	65	Dk	Dk (2)
5.5	5	dust 2/10	65	blowing	Dk (4)
5.6	7	W quad 8 miles		Dk	8
				Indefinite	
6.2	4	scattered	2500	Dk	25
6.3	3	broken	8500	25	8500
6.4	3	overcast	10000	85	10000
7.2	1	scattered	broken	100	
7.3	2	8000	25		
8.1	2	A00		ADO	2500
8.5	5	1 1/4 mi.		1/4	ROD
				11	
8.6	8	(thunder and heavy rain showers)	1 1/4	11 v B1 4	4
					1/4
				rain (sand and dust)	(rain showers) (3) (thunder and light rain)
				rain	rain showers

ELECTROLUMINESCENT DISPLAY WEATHER MESSAGES

QUESTION	# OF ERRORS	CORRECT RESPONSES	INCORRECT RESPONSES		
			Wx	GCA	PILOTS
9.1	1	PWM	AFM	30	3000
9.2	4	broken	scattered	scattered	
9.3	1	broken	Dk		
9.5	6	1 3/4 miles	3/4 (2)	3/4	3/4
9.6	1	(light thunder showers)	Dk		
10.2	3	(2 1/4 miles variable)	Dk	obscured haze fog (2)	
10.3	5	fog and smoke	Dk (partially obscured)	(intermittent rain)	(intermittent light rain) (2)
10.5	12	fog 1/10	Dk (very light rain)	(intermittent rain) (2)	(intermittent rain) (2)
10.6	4		Dk (light rain)	(intermittent rain) (2)	(variable 1/2 mile)
				2 v 2 1/2	2 v 2 1/4

ELECTROLUMINESCENT DISPLAY WEATHER MESSAGES

QUESTION	# OF ERRORS	CORRECT RESPONSES	INCORRECT RESPONSES	Wx	GCA	PILOTS
11.1	1	HAT				
11.2	3	overcast				
11.4	1					
11.6	1					
12.1	2	LEB	LED (2)			
12.2	2	scattered	broken			
12.3	2	scattered	broken			
12.4	3	scattered	broken			
12.5	26	115	1	Dk (5)	Dk (13)	Dk (13)
				2983	HIR	
				1487	(high rate increase)	
					2983 (2)	
					983	
					sirrus	
					FC	
12.6	25	low 4 SC middle 8 or AC high 7 CS	(scattered broken overcast) (HIR clouds VSBL at surface)	HIR clouds	fog	
					scattered	
					stratus	
					SFS	
					(variable surface)	
					high	
					Dk (9)	
13.3	2			West (2)		
				East (2)		

ELECTROLUMINESCENT DISPLAY WEATHER MESSAGES

QUESTION	# OF ERRORS	CORRECT RESPONSES		INCORRECT RESPONSES		PILOTS
		Wx	GCA	Wx	GCA	
14.2	1	8500 scattered		broken		500 broken
14.3	2	HAT		HRT		
15.1	1	ART		overcast		AKT south
15.3	1	ART				
16.1	1	north				
16.4	1	12 + 15 haze and smoke				
16.5	1	broken		scattered		
16.6	1	blowing dust		none		scattered Dk (9) virga NW
17.2	2			part. obs.	Dk (6)	obscured (partially obscured) (3)
17.5	25					temp. obscured variable NW thin obscured
17.6	5	dust 1/10		Dk		Dk (2) smoke
18.1	1	BDR				virga NW
18.3	1	scattered		clear		
					DDR	

ELECTROLUMINESCENT DISPLAY WEATHER MESSAGES

QUESTION	# OF ERRORS	CORRECT RESPONSES		INCORRECT RESPONSES		PILOTS
		Wx	GCA	CIE	GCA	
19.1	1	CLE		2500		
19.2	3	scattered		25		2500
19.3	2	broken		60		6000
19.4	2	broken		100		1000
19.5	2	overcast		250		2500
19.6	6	6 miles SW		65		65 (4)
20.1	2	SGV		EGV		
20.2	3	broken	scattered	30	3000	
20.3	3	broken	scattered	90	9000	
20.4	2	overcast		150	15000	
20.5	4	(light thunder showers and smoke)	smoke		smoke (rain showers) (light rain showers)	
20.6	1	1 1/2 mile		Dk		
21.4	1	thin broken		Dk		no
21.5	5	2400-2600	24 v 25			yes-2500 2500-8000 2500 and up
21.6	11	1 3/4 miles	3/4 (3)	3/4	3/4	3/4
			13	3	13	Dk
			3			2500-8000

ELECTROLUMINESCENT DISPLAY WEATHER MESSAGES

QUESTION	# OF ERRORS	CORRECT RESPONSES	Wx	INCORRECT RESPONSES	GCA	PILOTS
22.2	4	overcast	200 (2)	90	Dk (5)	9000 (3)
22.3	31	120	Po 1 001	1577-22 1577 2987	FLL falling falling (2)	Dk (9)
22.4	24	0V1	Dk (2) OV 1/2	OV 1/2 (2) 1V1 Dk (2)	Dk (5); 200 1/2 v to F OV 1/2 (2)	Dk (5); 200 1/2 v to F OV 1/2 (2)
22.5	25	low 5 middle 7 high 7	SC AC or AS CS	Dk (5) (scattered broken overcast) 22	Dk (5) BY fog (2) (scattered to overcast) stratus	Dk (12)
22.6	2		1/2 mile v	BKL	Dk (2)	broken 1 1/2
23.1	2		1/2 miles	1/2	Dk (2)	
23.3	1		rain	Dk	fog	
23.4	5		1 v 2	contrails (2)	Dk (3)	contrails (2)
23.5	8					1 1/2

ELECTROLUMINESCENT DISPLAY WEATHER MESSAGES

QUESTION	# OF ERRORS	CORRECT RESPONSES	INCORRECT RESPONSES	Wx	GCA	PILOTS
23.6	25	113		1	Dk (6)	Dk (10) FL
			Falling (2) Falling 1 (2)			
			raising raising			
			2996			
			2996 falling			
24.1	2	BAL	DAL (2)	50	5000 (3)	
24.2	4	overcast				
24.3	1	West				
24.4	1	2 miles				
24.5	4	fog 3/10				
66		ZRNOCNL				
25.1	2	BAF	DAF (2)			
25.3	17	Virga NW quad.	Dk (4)			
		(ground fog bank	NIRGA			
		N quad.)	Dk (2)			
			fog bank NW (2)			
			grd. fog NW (2)			
			(NW grd. fog			
			bank)			
			GF Ban NW HD			
			Var grd. fog NW			
			West			
			Dk			
			(Nort wind			
			dir. var.)			
25.5	3	variable				
25.6	1		29.25			
			295			

Unclassified

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13. ABSTRACT An investigation was undertaken to provide a human factors evaluation of an electroluminescent display designed for the presentation of around-the-base weather messages. Time and error data were obtained for 42 Air Force weather, GCA, and pilot personnel in responding to six questions for each of 50 weather messages, 25 of which were presented on an electroluminescent display and 25 by conventional teletype format. The few significant differences found do not warrant a conclusion that the electroluminescent format employed is inferior to the conventional teletype format. It is concluded that weather message information processing may be improved by the development of time and error normative data for a standard set of weather messages, thereby permitting the identification of high-error (perhaps error-prone) personnel, by training to improve the interpretation of visibility coding and more specifically, by an improved formating of fractions concerned with visibility. The suggestion for the development of normative data may have applicability for other military information systems. This study may be of assistance to the display designer and for the training of military and civilian personnel in weather message interpretation. It has value for the improvement of weather message formating as well as highlighting the importance of appropriate personnel selection and training for tasks involving the processing of information in complex displays. The study further demonstrates the importance of not relying upon premature curbstone judgments of a display feasibility in lieu of an actual experimental test.		

## Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
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DISPLAY ELECTROLUMINESCENT TELETYPE READABILITY EVALUATION HUMAN FACTORS INFORMATION PROCESSING WEATHER MESSAGES						
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